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Spontaneous Combustion as a Cause of Fires

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Abstract
The reports of the state fire marshal of Iowa for the years 1912- 1916 show that spontaneous combustion, or the overheating of a substance from causes within itself, is a very prominent cause of fires in the state. In the five years of the reports, spontaneous combustion has regularly ranked 5th or 6th among the various known causes of fires and the total number of fires traced to It annually hr.cs ranged from 83 to 153. In the amount of loss, it has ranked from 2nd to 6th among the known causes, Its total running as high as $468,599 in a single year.

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Spontaneous Combustion as a Cause of Fires

BY A. R. LAMB

The reports of the state fire marshal of Iowa for the years 1912-1916 show that spontaneous combustion, or the overheating of a substance from causes within itself, is a very prominent cause of fires in the state. In the five years of the reports, spontaneous combustion has regularly ranked 5th or 6th among the various known causes of fires and the total number of fires traced to it annually has ranged from 83 to 153. In the amount of loss, it has ranked from 2nd to 6th among the known causes, its total running as high as $468,599 in a single year.

TABLE I. Losses due to spontaneous combustion.

			Rank among known causes of fires	
Year	No. of fires	Loss	In no. of fires	In amt. of loss
1912	83	$100,782	6	6
1913	153	468,599	5	2
1914	131	261,045	6	4
1915	139	296,036	5	3
1916	153	209,153	5	6

Most of the losses due to spontaneous combustion are avoidable. They may be prevented by intelligent care and precaution, based on just a little understanding of what spontaneous combustion is and where and how it is likely to act.

Combustion in every day terms is "burning". The chemist describes it more carefully by saying that it is a kind of oxidation, accompanied by the production of heat, oxidation meaning the uniting of a substance with oxygen. In ordinary combustion the oxygen comes from the air. Combustion may be rapid and then it is what we commonly know as "burning". It is then accompanied by the very rapid production of heat and flame. But it may also be very slow, with a much slower and smaller production of heat and no flame. Combustion may be started by causes outside of the substance that is burned or oxidized, or by causes within. Spontaneous combustion arises from causes within a substance. The combustion, or burning, is in all cases very slow at first, but if the small amount of heat generated does not all escape, the rate of combustion may increase until the ignition point, or kindling temperature, is reached. At that point, the substance actually burns or bursts into flames.

There are three kinds of materials which are subject under certain conditions to spontaneous combusion. These are hay, coal, and so-called "drying oils."

SPONTANEOUS COMBUSTION OF HAY.

Clover and alfalfa hays seem to be most liable to spontaneous combustion, due probably to the fact that the stems do not dry out as easily as do the grasses. Whenever hay of any kind is stored in large masses when too green, or when wet with dew or rain, it will show some spontaneous heating. If the mass is large enough to retain most of the heat, and there is moisture in or on the hay to start a lively fermentation, the heating thus started may continue until the mass bursts into flame. One case of spontaneous combustion is reported in which the hay became so hot that when the hay near the surface reached the kindling temperature the mass burst into flame with explosive violence.

As far as known, only three conditions are necessary to produce spontaneous combusion, in hay-mows or stacks. These are the presence of moisture in the hay, the presence of a great enough bulk of the hay to retain heat, and sufficient ventilation to supply the necessary oxygen.

CAUSE OF SPONTANEOUS COMBUSTION IN HAY

The cause of spontaneous combustion in hay is not yet entirely understood. The first attempts to explain it generally gave fermentation as the only cause. However, it is manifestly impossible for fermentation processes to raise the temperature of the hay above the point at which the living cells are destroyed. Somewhere between 120° and 150° Fahrenheit all living cells are either killed or made inactive by the heat. Rapid combustion, or burning, does not begin until the hay reaches a temperature of about 400° Fahrenheit.

Therefore some other agents must assist in raising the temperature through the second stage.

Oxidation, which has been defined above as the uniting of substances with oxygen, may take place at ordinary temperatures. A typical example is the rusting of iron, which is the result of the formation of a compound of iron and oxygen. Other slow oxidations take place in plant substances, always liberating a certain amount of heat. The total amount of heat given off in a slow oxidation is exactly the same as when the substance is burned in a furnace, but usually the heat from a slow oxidation is lost as fast as it is formed. In a large hay-mow, however, part of the heat produced by the large mass of hay is retained, and helps to raise the temperature of the whole mass.

The most reasonable explanation of the manner in which the temperature of hay is raised to the ignition or kindling temperature, based on the experiments of various investigators is as follows: The process is begun by fermentation, in which bacteria and plant-cell respiration both play a part. The fermentation may raise the temperature to about 135° Fahrenheit. When the hay becomes as hot as this, the rate of the oxidations is greatly increased. The heat thus produced raises the temperature still higher, and the oxidation processes then go on still more rapidly. In the neighborhood of 200° Fahrenheit the hay will begin to char. Experiments have shown that charcoal will absorb a great deal of oxygen from the air. Naturally this assists the oxidation which goes on still more rapidly. Not all hay which becomes charred reaches the kindling temperature. This may be because not enough oxygen from the air reaches it. It has been said that in a very tightly built hay-mow with the floor and siding made with well matched boards, combustion may perhaps be prevented by keeping out the necessary supply of air.

If the hay has reached a dangerously high temperature, air should not be allowed to get to it. Therefore, attempts to remove the hay from a barn after it becomes very hot, generally succeed only in making a bad matter worse. The smoldering hay generally bursts into flames and burns very rapidly. In some cases, with plenty of help and a supply of water at hand, it is barely possible to remove the hay without allowing the flames to get beyond control. Tossing the hay about and making vents or chimneys in the mass will allow air to reach the hot interior and generally result in the complete destruction of the hay-mow or stack. If the hay has not reached the ignition temperature, it may be safely exposed to the air. In most cases, however, the evidences of heating are not very noticeable until the hay has reached a dangerous temperature.

PREVENTION OF SPONTANEOUS COMBUSTION IN HAY

The self-heating of hay generally reaches a dangerous point about a month or six weeks after being mowed or stacked. Means of prevention must, however, be employed before this time. The most effective means is proper curing of the hay before storing it. In some cases this is difficult to accomplish, but extra care and labor pay good profits. Hay which has heated in the mow has lost a large part of its feeding value, the amount depending on the amount of heating. If the hay heats to the danger point, it is rarely possible to save the barn or stack. As fire protection is generally at a considerable distance, surrounding buildings as well as valuable stock and farm implements are endangered. Even if the loss is all or nearly all covered by insurance, it is an absolute destruction and waste of our resources which cannot be replaced. Insurance merely divides the loss among a larger number of people. Therefore it pays to employ extra care and labor in properly curing the hay.

The stalks of alfalfa and red clover naturally retain moisture longer than the rest of the plant. The leaves, which dry quickly and are easily crumbled and lost, contain two or three times as much protein or flesh building food, as the rest of the plant. It is thus very important to prevent the leaves from drying out too much. However, the hay should be carefully cured until the stalks are so dry that no moisture can be squeezed out by twisting a bunch in the hands. It must also be free from outside moisture, as dew or rain, when put into the barn.

If the hay has unavoidably been put into the barn when somewhat moist it should be watched for signs of heating. The first evidence is shown in the morning, a day or two later, when the mow is covered with moisture condensed from the water vapor driven off in the heating. If the heating continues, craters or openings may be found near the center of the mow. If gases or pungent odors are given off, the heating is great enough to be dangerous, and the hay should be removed at once.

If the heating has become extreme before it is noticed, it is probable that a large part of the interior is charred. In one case reported in Kansas, a boy went on top of a stack and forced a pole through two or three feet of hay, when it entered the charred interior and dropped to the bottom. In a few minutes the stack was ablaze. The danger in going on top of such a stack or mow is plainly evident.

Certainly the best policy is to avoid danger by properly curing the hay before storing it.

SPONTANEOUS COMBUSTION OF COAL.

The tendency toward slow oxidation or combustion is present to a greater extent in coal than in hay. However, since there can be no fermentation to raise the temperature and start the process, as in the case of hay, coal does not generally ignite spontaneously unless stored in such large quantities, as those used by industrial plants and railroads, that the heat given off from slow oxidation is retained. The presence of finely crushed coal or dust, especially when mixed with larger lumps, appears to aid spontaneous heating. The lumps allow free access of air to the fine coal, which oxidizes more readily, on account of the larger surface exposed. It is said that moisture, especially alternate wetting and drying, aid spontaneous heating, but this has not been fully proved. Storage in the vicinity of a boiler, or other outside sources of heat, should be avoided. Even a slight rise in temperature hastens these oxidation processes and increases greatly the danger of spontaneous combustion. The experiments of the United States Bureau of Mines show that the sulfur in coal, in the form of pyrites, has very little effect on self-heating in coal.

Means of prevention consist mainly in avoiding external heat and limiting the size of the pile to 12 feet deep and 18 to 20 feet wide. The interior of the pile should not be ventilated by pipes or other means. The amount of handling should be minimized, thus reducing the amount of dust. However, a temporary storage will allow the coal to "season," and thus it will be less likely to heat later.

SPONTANEOUS COMBUSTION OF OILS.

The third and last important kind of spontaneous combustion is the cause of many destructive fires. Drying oils, such as linseed oil, which is used in paint, take on oxygen very readly in the air. This process is so rapid and the heat developed is so considerable that large amounts of such materials are not necessary to retain the heat, as in preceding cases. If a handful of cotton-waste or cloth of any kind, saturated with linseed or cotton-seed oil, be thrown down near any combustible material, a fire may be started in a few hours. Some other plant or animal oils possess the same property to a lesser degree. Mineral oils, as lubricating or cylinder oils, do not act in this manner

When linseed oil, for example, is in a pail or can, the proportion of its surface exposed to the air is very small. When spread on a pile of rags or waste, each fiber of the cloth exposes a film of oil to the air, infinitely increasing the amount of surface exposed and the rate of chemical action. Great care should be taken, when linseed oil is used for cleaning or in painting, to destroy oily rags or waste at once or leave them in a place where they can do no damage. Such materials are too often used and left in places where combustible substances, such as packing boxes, are at hand, and in buildings containing valuable stocks of merchandise or machinery. Such carelessness or ignorance is the cause of a large and unnecessary increase in the annual fire loss.